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# ***U.S. PATENT APPLICATION***

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***Invention:*** BYPASS AIR INJECTION METHOD AND APPARATUS FOR GAS TURBINES

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## ***SPECIFICATION***

## BYPASS AIR INJECTION METHOD AND APPARATUS FOR GAS TURBINES

[0001] The present invention relates to gas turbines, and more particularly, relates to a bypass air injection apparatus and method to increase the effectiveness of the combustor by quenching the combustion process.

## BACKGROUND OF THE INVENTION

[0002] Gas turbine manufacturers are currently involved in research and engineering programs to produce new gas turbines that will operate at high efficiency without producing undesirable air polluting emissions. The primary air polluting emissions usually produced by gas turbines burning conventional hydrocarbon fuels are oxides of nitrogen, carbon monoxide and unburned hydrocarbons.

[0003] Catalytic reactors are generally used in gas turbines to control the amount of pollutants as a catalytic reactor burns a fuel and air mixture at lower temperatures, thus reduces pollutants released during combustion. As a catalytic reactor ages, the equivalence ratio (actual fuel/air ratio divided by the stoichiometric fuel/air ratio for combustion) of the reactants traveling through the reactor needs to be increased in order to maximize the effectiveness of the reactor. Thus, there is a need to compensate for the degradation of the catalytic reactor.

## BRIEF SUMMARY OF THE INVENTION

[0004] Accordingly, the present invention is directed to a bypass air injection apparatus and method to compensate for the degradation of a catalytic reactor and to increase combustor efficiency by extracting compressor discharge air prior to its entry into a combustion or reaction zone of the combustor, and re-injecting the extracted compressor discharge air into the combustor bypassing the catalytic reactor using a plurality of injection tubes located substantially in a common axial plane with an injection manifold. Compressor discharge air is received by the combustor in a first combustion chamber through a passageway, preferably an annulus defined between a combustor body with an inner liner and a casing enclosing the body. The first combustion chamber includes a pre-burner stage where fuel is mixed with compressor discharge air for combustion, thus raising the temperature of the hot gases sufficiently to sustain a reaction with the catalyst disposed downstream of the first combustion chamber. Hot gases flowing out of the first combustion chamber pass through a main fuel premixer (MFP) assembly for combustion in a main combustion chamber disposed downstream of the catalyst.

[0005] A predetermined amount of compressor discharge air, flowing through the annulus, and prior to reception in the first combustion chamber, is extracted into a manifold. The extraction manifold is disposed adjacent to an array of openings located in the casing enabling compressor discharge air to flow from the annulus into the extraction manifold. A bypass conduit

connects the extraction manifold to an injection manifold. The injection manifold lies in communication with a plurality of injection tubes for injecting the extracted air into the combustor body bypassing the catalyst. As noted above, each injection tube and the injection manifold are disposed in a substantially common axial plane. Removable flange covers are provided on the injection manifold in substantial radial alignment with the respective injector tubes affording access to the tubes. The injection tubes are installed from the outside of the injection manifold at circumferentially spaced locations about the casing and the liner through flange covers. A bypass air(i.e., extracted air) path is therefore provided to bridge the backside cooling airflow annulus disposed between the combustor casing and the combustion liner.

[0006] In another embodiment, the combustor includes only one combustion chamber. Thus, the combustor is devoid of the catalyst and the MFP assembly. Here, main combustion occurs at the pre-burner stage where a greater amount of fuel is mixed with air in order for combustion to occur.

[0007] In one aspect, the present invention provides a combustor for a gas turbine having a combustor body with an inner liner; a casing enclosing the body and defining a passageway therebetween for carrying compressor discharge air; a combustion chamber within the body for combustion of fuel and air; a first manifold for extracting a predetermined amount of compressor discharge air from the passageway; a second manifold for receiving

the extracted air and supplying the extracted air into the body at a location bypassing the combustion chamber; and a plurality of injection tubes in communication with the second manifold for injecting the extracted air into the body to quench combustion, the injection tubes and the second manifold being disposed in a substantially common axial plane. The combustor further includes an array of openings disposed in the casing to permit the compressor discharge air to flow through the openings into the first manifold; and a conduit for supplying the extracted air from the first manifold to the second manifold. The second manifold preferably includes an access flange for each of the injection tubes. Preferably, the injection tubes are equally spaced from one another about the second manifold. The first and second ends of the conduit terminate in the first and second manifolds, respectively. The conduit includes a control valve to regulate air flowing from the first manifold to the second manifold. The first and second manifolds are preferably disposed about an outer surface of the casing.

[0008] In another aspect, the present invention provides a combustor for a gas turbine including a combustor body with an inner liner; a casing enclosing the body and defining a passageway therebetween for carrying compressor discharge air; a catalytic reactor disposed in the body for controlling pollutants released during combustion; a first manifold for extracting a predetermined amount of compressor discharge air from the passageway; a second manifold for receiving the extracted air and supplying the extracted air to the body at a

location bypassing the catalytic reactor; and a plurality of injection tubes in communication with the second manifold for injecting the extracted air into the body, the injection tubes and the second manifold being disposed in a substantially common axial plane.

[0009] In another aspect, the present invention provides a gas turbine having a compressor section for pressurizing air; a combustor for receiving the pressurized air; and a turbine section for receiving hot gases of combustion from the combustor, the combustor including a combustor body with an inner liner, a casing enclosing the body and defining a passageway therebetween for carrying compressor discharge air, a combustion chamber within the body for combustion of fuel and air, a first manifold for extracting a predetermined amount of compressor discharge air from the passageway, a second manifold for receiving the extracted air and supplying the extracted air into the body at a location bypassing the combustion chamber, and a plurality of injection tubes in communication with the second manifold for injecting the extracted air to the body to quench combustion, the injection tubes and the second manifold are disposed in a substantially common axial plane.

[0010] In yet another aspect, the present invention provides a method for quenching combustion by extracting a predetermined amount of compressor discharge air, before the air flows into the reactor, from the passageway into the first manifold; supplying the extracted air from the first manifold to the second manifold via the conduit; injecting the extracted air

received by the second manifold into the body at a location along the body bypassing the reactor using an array of injection tubes; and disposing the injection tubes and the second manifold in a substantially common axial plane.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIGURE 1 is a schematic cross-sectional illustration of a combustor forming a part of a gas turbine and constructed in accordance with the present invention;

[0012] FIGURE 2 is a detailed illustration of the injection manifold and the bypass injection scheme of the present invention;

[0013] FIGURE 3 illustrates another embodiment of the invention wherein a catalytic reactor is removed from the combustor; and

[0014] FIGURE 4 shows a section of the combustor casing, of Figure 1, having an array of openings for extracting compressor discharge air.

DETAILED DESCRIPTION OF THE INVENTION

[0015] As is well known, a gas turbine includes a compressor section, a combustion section and a turbine section. The compressor section is driven by the turbine section typically through a common shaft connection. The combustion section typically includes a circular array of circumferentially spaced combustors. A fuel/air mixture

is burned in each combustor to produce the hot energetic gas, which flows through a transition piece to the turbine section. For purposes of the present description, only one combustor is discussed and illustrated, it being appreciated that all of the other combustors arranged about the turbine are substantially identical to one another.

[0016] Referring now to FIG. 1, there is shown a combustor generally indicated at 10 for a gas turbine including a fuel injector assembly 12 having a single nozzle or a plurality of fuel nozzles (not shown), a cylindrical body 16 with an inner liner 15, and a casing 20 enclosing the body 16 thereby defining a passageway 18, preferably an annulus 18 therebetween. An ignition device (not shown) is provided and preferably comprises an electrically energized spark plug. Discharge air received from a compressor 40 via an inlet duct 38 flows through the annulus 18 and enters the body 16 through a plurality of holes 22 provided on the body 16. Compressor discharge air enters body 16 under a pressure differential across the cap assembly 21 to mix with fuel from the fuel injector assembly 12. The mixture is burnt by the pre-burner assembly 11. Combustion occurs in a first combustion chamber or first reaction zone 14 within the body 16 thus raising the temperature of the combustion gases to a sufficient level for the catalyst 27 to react. Combustion air from the first combustion chamber 14 flows through a main fuel premixer (MFP) assembly 24 and then through catalyst 27 into the main combustion chamber or main reaction zone 29 for combustion. Additional fuel is pumped into the MFP

assembly to mix with hot gases, exiting the first combustion chamber 14, thus producing a combustion reaction in the main combustion chamber 29, whereby the hot gases of combustion pass through a transition piece 36 to drive the turbine (an inlet section of which is shown at 42).

[0017] A predetermined amount of the compressor discharge air is extracted from the annulus 18 into a manifold 26 via an array of openings 25 (Figure 4) located in casing 20 and leading into an opening 28 which sealingly mates with one end of a bypass conduit 30, while a second end of conduit 30 leads into an injection manifold 32. A valve 31 regulates the amount of air supplied to manifold 32. Air received in manifold 32 is injected by a plurality of injection tubes 33 into body 16, bypassing catalyst 27. Each of the injection tubes 33 and manifold 32 are located substantially in a common axial plane. Further, each injection tube opens into body 16 through apertures 34 (Figure 2). Removable flange covers 23 are provided on the injection manifold in substantial radial alignment with the respective injector tubes 33 affording access to the tubes. The injection tubes are installed from the outside of the injection manifold at circumferentially spaced locations about the casing and the liner through flange covers. Members 35 and 39 (Figure 2) cooperate to secure each injection tube 33 to body 16 in a floating seal to provide a sealingly tight connection. Thus, injected air cools the reaction and quenches the combustion process.

[0018] Referring to Figure 3, a second embodiment is illustrated wherein like elements as in the combustor of Figure 1 are indicated by like reference numerals preceded by the prefix "1". Here, the combustor 110 comprises a combustion chamber or reaction zone 114 where main combustion occurs. Catalyst 27 and MFP assembly 24 are absent in this embodiment. Here, compressor discharge air from annulus 118 flows into manifold 126, and from manifold 126 via conduit 130 flows into body 116 through injection tubes 133 bypassing the combustion chamber 114. Further, the amount of fuel supplied to mix with compressor discharge air is greater than the amount supplied in the presence of a catalyst. It will be appreciated that the location of the combustion chamber 114 need not necessarily lie in close proximity to the fuel injector assembly 112. Rather it may be located within body 116 between end member 143 and manifold 132. Likewise, manifold 132 may be appropriately located along casing 120 to inject air into body 116 provided the combustion chamber is bypassed in order to quench the combustion process.

[0019] Thus, the present invention has the advantages of maximizing the effectiveness of the catalytic reaction, thereby increasing the efficiency of the combustor. The present invention further provides a simple means of controlling the combustion process.

[0020] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the

disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.